

varying distances outwards, equal barometric readings form a series of rings round this : the outer ring having the highest reading, and the rest being graduated towards the centre.

The wind does not circle round a cyclone in true circles at all altitudes.

Near the sea level the wind forms the greatest in-going angle with the isobars and this angle gradually decreases, till at an altitude which varies with its position with reference to the cyclone the wind flows parallel to the isobars. Above this point the wind has a gradual out-flowing tendency, which reaches its maximum at the point where the cyclonic influence ceases.

Below this turning point of the wind's direction, clouds are very seldom seen, but when anything approaching to a cloud is formed, it takes the appearance of fog. Hence I call this, the fog bearing stratum. The next region of the atmosphere where the winds have a tendency to circle outwards is the stratum of the very lowest clouds. Above this is the great upper current. This current can be divided into two distinct portions ; the lower, which is considerably modified by the direction of the cyclonic centres, and the upper portion which from day to day, month to month, and year to year always flows from some point near north-west, and which is in fact the true compensating upper return current of the trade winds.

The former of these is the stratum where the heavy cumulus and cumulo-stratus cloud is formed, while the latter is the home of the cirrus cloud.

Now if the whole solid contents of a cyclone could be rendered visible to one situated externally to it, what would be its general appearance? I will try to make this clear. Suppose we take an inverted cone, perpendicular to the surface of the sea. If the apex be immersed in the sea till the circle thus formed round the cone be equal to the surface area affected by the cyclone, and we then cut off an ellipse, the one edge of which shall touch the sea and the opposite edge be elevated considerably above it, the solid figure contained between this ellipse and the sea level will be the true form of a cyclone, providing you dish the surface of the ellipse towards the centre.

The next question which it is but natural to ask is—how can you prove this? A question which I will try to answer.

I shall answer this question by asking another. Why do cyclones travel from west to east?

We often hear it said that cyclones travel round the sides of areas of

high pressure. But supposing no such high pressure to exist, what then? And in any case it must be confessed that the barometer is higher in front of a cyclone than it is nearer the centre, and consequently the low must move to the high. If we assume that a low cannot flow towards a high, then a cyclone must stand still unless the high moves forward. But we very often see a high only giving way when a cyclone forces it to do so, the result being some very stiff blowing, shewing that the high dies very hard. Moreover in a great number of cases the cyclone splits the high into two and forms what is now commonly called a "col" or neck. Hence the greatest energy must be in the cyclone, and the initial motive power moving it from west to east must be in itself.

And what is this power? Nothing more nor less than the circulation of winds round the centre.

Let us imagine a cyclone to be situated over the South Atlantic ocean to the west of us. The winds are blowing round the centre in the same direction that the hands of a clock travel round the dial. But these winds are of two kinds, one totally different from the other; for whereas the front wind is an equatorial one, that at the rear is a polar one.

The equatorial wind, or that which blows from the north is a warm one, which causes the atmosphere to increase considerably in bulk for an equal amount of pressure. Moreover this current is heavily charged with moisture. But with the polar wind the converse is the case; for here though the pressure remains the same, the bulk will be much less.

We will now imagine two points at equal distances from the centre, one to the east and the other to the west. At both points the barometer reads 30 inches, but there is a marked difference in the atmospheric conditions of the two places, for whereas at the easterly point the warm and rarified air extends to a great height, at the westerly point the air being denser does not extend to such an altitude. Thus the upper surface (so to speak) of the cyclone forms an angle with the sea level, the line of which if extended to the west would cut the sea at the spot where the cyclonic influence ceases, but if extended to the east would overlap the general surrounding atmosphere and so complete the portion of the cone. It will thus be seen how my figure of the inverted cone is borne out.

From the foregoing it will have been perceived that for equal pressure the air is much more rare on the advance side of the centre than on the following.

In fact the *rarest* portion is that in advance of the centre. The

atmospheric pressure is least at the centre, but the air is not the most rarified there.

One of the laws of atmospheric equilibrium is, that dense air always flows towards that which is most rarified and as the air in the advance half of the cyclone is more rarified than that at the centre, it is easy to see how this centre moves from west to east, and as the whole system of winds travels with the centre, the front will always draw the centre onwards.

When a hot stream of water is encountered the cyclone travels along it, because the equatorial air current is more heated there than elsewhere. The Mozambique current is one of this sort, our winter storms generally travelling along it.

But there is another peculiarity as being the result of the opposite winds which affect stations of medium height, and isolated like Cape Point, which will best be described by an example.

Let us once more return to our cyclone which has been patiently waiting over the South Atlantic Ocean. No, not patiently waiting, for while we have been considering its physical conditions the advance winds have reached Cape Point.

Simultaneous readings are taken at the various stations, reduced to 32° and to sea level, and lo ! Cape Point reads too high by about a half a tenth of an inch.

Why is this ? The reading was correct and so was the reduction. Then why this discrepancy ?

If you consider for a moment you will see that such must be the case. Assume the atmosphere greatly rarified, with a sea pressure of 30 inches, then the height of the air column must have been considerably increased, and a greater amount of air must exist above Cape Point than would be the case if the air were more dense, but as the reduction additions to both are the same, providing of course that the temperatures are the same, this will make the reduced reading for rarified air higher than it would be if the air were dense. The converse of all this will be the case on the other side of the cyclone.

Let us now retrogress a little and imagine our cyclone just outside the colony and advancing on to it. Owing to the wedge-shaped form of the advance disturbed portion, isolated peaks will be the first to feel it. Cape Point being such a station we will imagine ourselves there and follow the sequence of the weather. A low pressure lies over the centre of the Colony, the wind at Cape Point is consequently south-east. Below, at sea level, it is south.

Suddenly a haze is seen to the north-west from which long thread-like clouds stream out which gradually spread over the whole sky. The general direction of these thread-like clouds is from north-west to south-east. These are what the Rev. Clement Ley calls *cirro-filum*, of which I will speak again.

Following these threads comes a bank of numerous small rounded cirrus clouds, close together, like an immense flock of sheep. These come driving up from the north-west, and as time passes on they grow larger and larger and seem to run one into the other. Towards the northern horizon they form themselves into a compact white sheet.

At the back of this mackerel sky, a thin hazy film begins to shew. Meanwhile the wind calms down at the peak, while it still blows at the sea. Slowly the vane goes round and a north wind springs up. The advance of the wedge is on us. Let us now take our instrumental readings. They are taken, telegraphed to headquarters, and reduced. The barometer is a half or a quarter of a tenth higher than it should be, while the temperature has risen considerably from what it was at the same time the day before; the wind too is north, while the general surface current is south and south-east.

Slowly the north wind travels down the sides of the peak till this is the only current observable. The advance of the cyclone is now fairly over the Cape Peninsula, and the usual sequence of falling barometer, changes of wind, &c., follows. When the depression has passed, the wind goes to the west or south-west, often blowing a gale.

Suddenly round goes the vane to south-east again, very often blowing strong while the south-west wind gradually calms down at the sea level. The storm has passed, as the dense atmosphere, too heavy to reach Cape Point, testifies; that peak experiencing the general trade wind circulation of the atmosphere. But should the vane back to north-west or north, no matter what its direction below, another disturbance will follow. Hence we see how important a station Cape Point might become in the prediction or fore-casting of weather, more particularly the winter storms.

I cannot pass over this portion of my paper without reference to my sun-spot theory. It will no doubt be fresh in the minds of most here that a paper upon this subject was read before this Society in July last, in which I shewed that a relationship existed between the positions of the spots on the solar disk and the various storms which

visit the Cape. Now if further investigations prove this of any practical value, so that we shall be able to tell for a definite period of time beforehand what nature of a storm to expect at even an approximate date, what an important warning station might not Cape Point be converted into. The sun spots will tell to a day or two when the storm is to be expected, and the observer at Cape Point could telegraph at least, and often more than, 24 hours, before its arrival, that it was close at hand.

Having given a general idea of the subject, I now wish to place before you some dry facts and figures. I will confine myself to this year alone. From the first of January to the end of August there were 38 separate cyclones from the north-west, west, or south, purely of the winter type. Taking the state of the barometer on the day of the storm, and on 1, 2 and 3 days before, the following results come out :—

The barometer was high, 11 times 3 days before the storm.

“	“	7	“	2	“	“	“	“
“	“	13	“	1	“	“	“	“

and 17 times on the morning of the storm.

Thus we find that during this period, twenty-three storms were foretold by an increase of pressure from one to three days before the storm, while seven had an increase *only* on the morning of the storm. The total of storms so foretold is thirty. This leaves eight storms un-indicated by increased pressure within three days of their appearance.

But increased pressure is not the only thing to be guided by ; increase of temperature is another indication, which I think the following will pretty well demonstrate.

Taking the same time as before we find that the maximum thermometer reading at 8 a.m. was 3 days before the storm 7 times.

2	“	“	“	“	3	“
1	“	“	“	“	16	“

and on the day of the storm 12 “

Two of the maxima for three days before must be omitted as they were lower than the readings of the days before, but on these days very strong barometer indications are noticeable.

With reference to the wind changes, one reading a day, and that at the very worst time, is hardly enough to construct anything like tables with.

On several occasions the wind blew from a similar direction on the

morning after the change at Cape Point to that at the other stations. This has been put down as a simultaneous change, while in reality the wind might have changed at Cape Point at a totally different time to the other stations. Twenty-four hours is a long period to pass over without an observation.

Roughly speaking the following are the wind changes :—

On fifteen days the wind changed at Cape Point before it did at the other stations.

On fifteen days the change was simultaneous.

And on three days the change did not take place at Cape Point till *after* the lower current had changed. These last three I am inclined to consider as due to wrong observations or to temporary whirls. The remaining five instances are very doubtful as the wind was blowing from the north-west all over the Cape Peninsula most of these times ; hence no change seemed to take place.

From the foregoing, the following inference may be drawn.

When there is either an undue increase of pressure or heat at Cape Point, a westerly depression may be looked for, especially if the wind is blowing from the north there, no matter what the direction may be below.

I have already mentioned that one of the forerunners of a storm is the appearance of a number of thread-like cirrus forms, called by the Rev. Clement Ley, Cirro-filum, but noted down by me long before I ever heard of Ley's name as thread cirrus.

This cirro-filum is formed at the junction of the two strata of the upper current. The upper stratum of this current always flows from some point between west and north-west, but the lower stratum is more or less affected by the cyclonic disturbances, very often travelling from south-west, but more often travelling from a similar direction to its upper component, although I have noticed it to travel from the south, when any great disturbance was at hand or just passed.

Now if a cyclone is advancing from the west or south-west, the advance edge of the cone will affect the motion of this current, the general direction of which will be more westerly. It will also become more charged with moisture. This moisture will form into cumulus clouds with perfectly level bases and sharply defined rounded tops. The more moisture is added to these clouds the higher they will become till, impinging on the upper current, their upper portions will be drawn out into long threads by this upper current travelling more quickly.

A great quantity of the electricity contained in these cumulus clouds will be dissipated into the upper stratum and the particles of water will coalesce and fall as rain. As long as the cloud receives fresh supplies, the cirro-filum will stream off and the rain fall, but as soon as the supply ceases the rain will also cease and the cirro-filum break up into ordinary cirri. As soon as a fresh supply of moisture is received, more cirro-filum clouds will be formed, in their turn to break up. It is thus we see such varying banks of cirri roll over us without a single cloud of medium altitude being seen, those generating clouds being far below the horizon, but surely advancing towards us. An expert if he but knows the point of the compass from which the threads seem to radiate and the direction they are travelling from, can tell exactly what the directions of both currents are.

Cirro-filum is a sure forerunner of rain. For the last two years I have seldom known this indication to fail. And where rain did not follow at Cape Town it was experienced further up-country.

I intend to introduce as a concluding portion to my paper some descriptions of one or two good typical winter storms which have visited us this year, with an account of the indications of their approach.

The first of these is a double depression, one which came from the north-west, immediately followed by a very severe one from the south-west. The whole disturbance extending from the 11th to the 17th August last.

On the 11th the only indication of a coming depression was the thermometer at Cape Point which at 8 a.m. was 3° higher than on the morning before. The general wind was south. On the 12th although the heat was the same, yet the barometer was $\cdot 09$ of an inch too high, shewing a rapid advance. As the general wind was south, and that at Cape Point south-east, the indications were for a depression from the north or north-west. Next day, the 13th, the heat was 2° higher, while the barometer was $\cdot 07$ of an inch too low at Cape Point, the wind blowing a south-east gale. By the low barometer the first depression had passed, and by the high thermometer another one was not far off. On the 14th neither barometer nor thermometer gave any indications, but the prevailing wind was north-west, while at Cape Point it was north-east; when the exact changes took place of course I cannot say, but the indications were for an approaching cyclone from the south-west. On the 15th the

thermometer at Cape Point had risen 2° and the barometer read $\cdot 09$ of an inch too high. The general wind was north, being fresh at Cape Point. On the 16th the storm was on us in all its fury. On the 17th this depression was passing away to the east and an anti-cyclone forming over the Colony.

The first of these two was a dry depression, as far as Cape Town was concerned, no rain falling. The first rain that fell was on the night of the 14th in advance of the second depression.

This second storm shewed itself to Cape Town observers by means of the upper currents while the first one was advancing on us, for on the 11th cirro-filum was developed all over the sky radiating from north-west to south-east, remaining there all that day and a part of the 12th, after which the sky remained clear till the 14th, when it became overcast. On the 15th at 8 a.m. my gauge registered $\cdot 055$ of an inch of rain, but on each of the following mornings three-tenths of an inch was measured, while on the 18th as the storm had passed, only $\cdot 16$ of an inch was gauged. The self-recording anemometer at the Royal Observatory bears out the foregoing description of the tracks of these two storms, as also do my own daily charts.

The next example I shall give will be that of a storm which I predicted two days before, merely by noticing the direction of the clouds, in the lower stratum of the upper current.

On the morning of the 21st of August last, a well-defined depression of the summer type lay over the Colony. The wind over Cape Town was south. Heavy low damp stratus clouds were driving from the south, while above Table Mountain some heavy cumulo-strati were moving at a moderate speed from the west. What made these clouds move from the west when the general direction was south? Nothing could do so but the advance wedge of an approaching cyclonic cone, and that cyclone must have been to the south. Hence I noted down the prediction that a depression was to the south of us and would strike the Colony in about two days. On the 22nd the barometer had fallen considerably, but this was due to the near approach of the northern cyclonic centre. The thermometer at Cape Point had risen 7° from the morning before, the wind there being east: at that time, (that is 8 a.m.) it was veering to the north. During the afternoon the barometer at Cape Town reached its minimum, and a nor-westerly wind sprang up. As the barometer began to rise slight showers fell which continued during the night, the wind freshening. On the morning of the 23rd the centre of the depression was off East

London, the whole Colony to Kimberley and Bloemfontein being affected by it. Fresh north-west and west winds blew all over the Colony.

The rainfall in Cape Town was moderately heavy, being $\cdot 36$ of an inch in my gauge on the morning of the 24th. On the whole of the 23rd, in fact, the weather was very stormy and squally, especially during the evening when some very heavy squalls were experienced. On the morning of the 22nd the Cape Point barometer read $\cdot 02$ of an inch higher than it should, which indicated another depression and sure enough during the day a small secondary passed.

One peculiarity of the wind at the Royal Observatory as self-recorded is that from 7 a.m. till midnight on the 23rd the wind although generally calm as registered by the mileage trace, yet passed in a series of squalls which kept on continually altering the direction of the vane from north-west to west, back to north-west then to south-west and south-east, back through west to north-west and repeating itself over and over again many times each hour.

It is in cases like these that the anemometer trace fails to indicate the intensity of individual gusts. One gust at half-past-eleven is visible on the trace as a very slight horizontal line. The speed at which the cups must have revolved for this short time must have been inconceivable.

There are a few more of these faint horizontal marks, but the one I have mentioned is the most conspicuous.

I could go on multiplying cases if I liked, where storm after storm passed, but there would be such a sameness about each one that it would become very monotonous, as the general sequences are the same, the only variation being due to the directions they come from, and the tracks of the centres. If they come from the north-west they are preceded by south-east winds which suddenly go round to the north-west as the centres pass; but if they come from the south-west, they are preceded by north-west winds, which chop round to the west as the centres pass.

These latter are the ones which bring the most rain to this end of the Colony. The reason of this is that the left-hand half of the cyclone is the wet half, so that if a storm comes from the north-west and passes us to the north-east, we are the whole time in the dry half of the cyclone.

At the beginning of this paper I mentioned that the Table Cloth on Table Mountain was due to the presence of the lower stratum of the

return equatorial current at a level of 3,000 feet above the sea. I promised to speak more on this subject and I may as well introduce it here before concluding. You will remember I said that when the contour of a country was gradual the atmospheric currents did not flow round but up it. It is thus with the backbone of the Cape Peninsula. From Cape Point the slope is gradual to the high table land behind Simon's Town. From there it is comparatively level (with the exception of the slight depression at Noord-Hoek) right on to the Constantia and Muizenberg range. From Hout Bay the slope is gradual up to the back of Table Mountain and the Twelve Apostles range.

Thus when a south wind blows round this end of the Cape Colony, the wind instead of flowing round the Cape Peninsula is carried up the sloping backbone before mentioned and impinges into the lower portion of the return current.

Now as this return current is warm and charged with moisture, the cold dry southerly current rushing into it condenses the moisture into the heavy cumulo-stratus cloud which we commonly called the Table Cloth.

As the wind whirls over the cliffs of Table Mountain it once more reaches the lower and colder stratum; the particles of cloud meanwhile having a propulsive and upward tendency are soon dissipated, the general appearance being that of a cloud constantly being formed and as constantly disappearing, a phenomenon familiar to us all. This is briefly the cause of the south-east cloud.

When the high pressure belt is further to the south and the return current exists *above* Table Mountain, or else when the general currents are southerly, no cloud can form. We have then what is commonly called a *blind south-easter*.

A black south-easter is not a south-easter at all but a south-wester, and is generally the following wind of a winter depression.

There is still one investigation which would be very beneficial to the study of the tracks of winter storms, and that is, the annual position of the South Atlantic anticyclone. The position of this has a great influence on the direction from which the storms come to the Colony, and as this direction affects the rainfall, it will be seen how important it would be to be able to tell exactly for a year or two in advance, from which direction the storms would come upon us.

I have no doubt that when this is investigated it will be found to have a cycle agreeing with the sun spot period of about eleven years.

I do hope that someone will be stirred up with an ambition to solve this problem, which is of such importance to a colony depending for its prosperity on its rainfall. - Paper after paper has been read on the subject of South African Meteorology, and still no one seems stirred with any desire to further its study, except a few who have to struggle alone and overcome difficulties greater than most people imagine exist, for I do not believe there is a more disheartening study in the world than that of Meteorology, and especially that of South Africa.

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September, 1886.

CAPE POINT.

Height of Thermometer, one, two and three days before a winter Storm, and on the morning of the Storm.

No. of Storm.	Days before Storm.			Day of Storm.
	3	2	1	
1	63	63	66	65
2	66	68	65	69
3	65	65	67	65
4	64	65	64	70
5	63	62	64	66
6	60	64	67	67
7	58	59	60	58
8	60	55	58	60
9	60	62	67	61
10	62	64	68	58
11	57	58	59	59
12	57	60	64	No record
13	63	56	60	68
14	57	56	56	68
15	68	56	61	59
16	53	52	53	53
17	53	54	50	54
18	50	54	58	60
19	60	54	51	50
20	49	52	53	53
21	53	52	55	55
22	57	51	53	55
23	55	54	62	54
24	55	51	60	64
25	62	56	57	48
26	49	50	58	51
27	51	54	52	53
28	52	53	50	52
29	48	52	54	58
30	50	50	59	53
31	53	53	52	50
32	50	45	45	53
33	58	56	62	70
34	52	52	51	51
35	46	49	49	51
36	51	50	52	52
37	51	43	50	50
38	50	49	53	53
	56.1	55.2	57.5	56.2

CAPE POINT.

Differences between barometer readings reduced to sea level and as indicated by the isobars, on one, two and three days before a winter storm, and on the morning of a storm.

No. of Storm.	Days before Storm.			Morning of Storm.
	3	2	1	
1	...	...	...	+·04
2	...	...	-·02	+·05
3	...	...	-·02	+·02
4	...	-·07	...	...
5	...	...	+·05	No record
6	-·03	...	+·04	...
7	...	...	+·04	+·02
8	...	...	...	+·05
9	+·05	...	+·05	+·02
10	...	+·02	-·03	...
11	-·04	+·05	...	...
12	-·02	-·02	...	...
13	-·02	+·02	...	+·03
14	...	-·03	...	+·05
15	+·05	...	+·03	+·07
16	-·02	-·02	..	+·05
17	+·05	+·03	+·02	...
18	+·02	..	...	...
19	...	...	...	...
20	+·02	...	...	...
21	...	...	..	...
22	-·03	+·03	+·02	+·02
23	...	..	...	...
24	...	...	...	...
25	..	+·04	+·04	...
26	+·03	...	...	+·06
27	+·06	...	...	+·05
28	...	+·05	...	+·03
29	...	...	...	...
30	+·04	...	...	...
31	...	...	+·06	+·04
32	+·04	-·06	...	...
33	...	...	-·02	...
34	+·04	...	+·03	...
35	...	..	+·09	-·07
36	-·07	...	+·09	...
37	...	...	...	+·02
38	+·02	...	+·04	+·02
Totals	11	7	13	17
Totals	7	5	4	1
				Too high
				Too low